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System and Methods for Adjusting Color Gamut Based on Printer Consumable Condition

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SYSTEM AND METHODS FOR ADJUSTING COLOR GAMUT BASED ON PRINTER CONSUMABLE CONDITION

TECHNICAL FIELD

The present invention relates to replaceable printing device components that are consumed during the printing process and, more particularly, to the adjustment of the color gamut of a print device to compensate for the condition of these consumable components.

BACKGROUND

Most printing devices are equipped with replaceable components having life cycles during which the replaceable components are functional. These components, often referred to as consumables, include toner cartridges, ink cartridges, ribbon cartridges, fusers, photoconductors, drums, transfer belts, and the like. Consumables such as paper, toner and ink are consumed with each printed page because they make up the printed product. Other than paper, toner or ink cartridges are the most commonly replaced consumables. Consumables such as fusers, photoconductors, and transfer drums or belts, are consumed with each page printed due to deterioration, and are not usually replaced as often as toner or ink cartridges.

There are a number of ways printers generally respond to deficient consumable conditions, such as an empty toner cartridge. For example, some printers respond to an empty toner cartridge by notifying the user and rejecting print jobs. This response can occur in the middle of a print job, or it can occur when a print job is initially sent to the printer. Either way, the user is required to fix the deficiency (e.g., locate and install a new toner cartridge) before the printer will accept or complete a print job.

Other printers do not notify the user of a deficient consumable condition, but simply continue printing. The user is left to discover that the print quality has

deteriorated to an unacceptable level and that print jobs will need to be repeated. With non-color printers, a low toner level may be tolerable for brief periods because the gradual lightening of the print output may not be immediately unacceptable. Users generally have an opportunity to replace the toner cartridge prior to the print quality becoming unacceptable.

However, with color printers the affect of the depletion of toner is more pronounced. Color printers typically use the four primary toner colors of cyan, magenta, yellow and black, and a depleted toner color often results in unacceptable streaking, fading of colors and/or change of hue. For example, the color green requires a mixture of cyan and yellow toners. Therefore, an expected green background may streak or fade from green to cyan as the yellow toner level runs low. The reduced print quality is thus quite apparent, and the user ordinarily must locate a replacement toner cartridge or forego the print job.

In addition, color printers often use a single all-in-one toner cartridge that contains all four of the primary toner colors. Because the absence of one toner color typically results in unacceptable print quality, a user cannot continue using the remaining color toners in the cartridge, but instead must replace the cartridge. Having to replace the entire cartridge because one toner color is depleted is a waste of the remaining color toners.

Various methods of modifying printer behavior based on consumable conditions have been developed. For example, monitoring devices have been used to detect when a consumable is nearing the end of its life cycle. The devices signal a user prior to the time when a consumable reaches the end of its life cycle so that the user can replace the consumable before the printer begins rejecting print jobs or before the print quality becomes unacceptable.

A specific example is a "toner low" signal from a print device. Upon seeing the "toner low" signal, the user can go about replacing the toner cartridge in a leisurely

manner. Monitoring the toner level and notifying the user prior to the complete depletion of the toner, avoids the hassle of having to immediately locate a replacement cartridge in order to resume printing or maintain print quality.

Another method of modifying printer behavior based on the condition of consumables involves the use of memory devices located on the consumable components. For example, toner cartridges can be manufactured with memory integrated into the cartridge. The memory is used to store printer related data that the printer reads to determine certain printing parameters. The data generally includes the number of pages that are expected to be printed during a toner cartridge life cycle. Therefore, the printer can notify the user as to how many pages remain to be printed by the cartridge. Again, this allows the user to replace the toner cartridge in a leisurely manner and avoid having to immediately locate a replacement toner cartridge in order to resume printing or maintain acceptable print quality.

Unfortunately, these prior methods of addressing deficient consumable conditions do not always solve the problems they are intended to solve. For example, although a user knows a toner cartridge may be close to empty because of a "toner low" signal, the temptation to put-off locating a replacement cartridge often results in the user waiting too long to take action. Therefore, toner cartridges frequently end up being completely depleted despite providing "toner low" warning signals. The problem of having to quickly locate a replacement cartridge in order to resume printing or maintain acceptable print quality thus remains.

Furthermore, these prior methods do not address the problem of wasted color toner that results from having to replace all-in-one toner cartridges just because one of the colors is low or depleted.

Accordingly, the need exists for a way to manage consumable conditions that does not result in the termination of a print job or unacceptable print quality in print

jobs. In addition, the need exists for a way of utilizing the remaining color toners in an all-in-one color cartridge that has run out of one of the color toners.

SUMMARY

A printer system adjusts the color gamut available for print jobs based on consumable conditions in a print device. Color gamut, as used throughout this disclosure, refers to the range of colors that is reproducible by a print device.

When a non-optimal consumable condition is detected, such as an empty toner color, adjustment of the color gamut permits continued printing in a reduced feature mode. Instead of stopping a print job or continuing to print with unacceptable print quality, the printer system offers choices for managing the non-optimal consumable condition. For color print devices using all-in-one toner cartridges, the ability to continue printing in a reduced feature mode avoids some of the waste normally associated with having to replace the entire cartridge when only one of the toner colors in the cartridge is depleted.

In a specific implementation, a printer system includes a host computer coupled to a color print device. The host computer includes printer control logic and a display device. The print device includes a consumable component such as a color toner cartridge that is configured with a monitoring device. The monitoring device monitors the condition of the toner cartridge and notifies the host computer in the event of a non-optimal condition (e.g., a low or empty toner cartridge). Therefore, with respect to any print job, the host computer may receive an indicator that the condition of a consumable component is non-optimal.

The printer control logic responds to a non-optimal consumable condition by informing the user that a toner color has been adversely affected by the condition and by visually displaying the print job on the host computer as it will appear in printed form

without the affected toner color. Therefore, where a toner color has been exhausted, the print job will be displayed on the host computer without the exhausted color. In addition to displaying the non-optimal print job, the printer control logic presents the user with options for managing the non-optimal consumable condition.

One such option is to have the computer suggest one or more alternate color schemes for the print job that do not include the missing toner color. A user may select an alternate color scheme and have the print job resubmitted to the print device for printing with the alternate scheme. The color gamut available for printing the job is adjusted according to the alternate color scheme by mapping the print job to a look-up table that replaces non-reproducible colors with reproducible colors. Adjusting the color gamut based on an alternate color scheme permits the print job to proceed without being canceled, avoids the unacceptable fading or streaking between colors that occurs when a toner color is low or empty, and forestalls the need to replace the missing toner color. In addition, where all-in-one color toner cartridges are used, the ability to put-off replacing the depleted toner color while maintaining acceptable print quality permits continued use of the remaining toner colors that would otherwise be wasted if the cartridge were replaced.

In addition to alternate color schemes, the printer control logic presents various other options for managing the non-optimal consumable condition. These options include canceling the print job, permitting the print job to print with the non-optimal condition, deactivating the affected toner color before printing the print job, redirecting the print job to an alternate print device, pausing the print process to permit correction of the non-optimal condition, and printing the print job in grayscale.

BRIEF DESCRIPTION OF THE DRAWINGS

The same reference numbers are used throughout the drawings to reference like components and features.

Fig. 1 illustrates a workstation and a printing device as a suitable system environment in which to adjust a color gamut based on the condition of a consumable component of the printing device.

Fig. 2 is a block diagram illustrating a system such as that in **Fig. 1**.

Fig. 3 illustrates a printer device which uses various consumable components.

Fig. 4A is a flow diagram illustrating an example method of printing where an alternate color scheme is made available for a print job based on a non-optimal consumable condition.

Fig. 4B is a continuation of the flow diagram of **Fig. 4A**, illustrating the basic operations taking place when a color gamut is adjusted.

Fig. 5 is a flow diagram illustrating an example method of printing where a color gamut has been adjusted because of a non-optimal consumable condition.

DETAILED DESCRIPTION

The system and methods described herein relate to managing a printing process based on the condition of consumable components of a color printing device. System users are notified of non-optimal conditions in consumable components and presented with options for how the system may proceed in processing a print job. The options include having the system suggest one or more alternate color schemes that avoid the non-optimal condition while providing the most likely acceptable alternative to a user. If the user accepts an alternate color scheme, the system adjusts the color gamut (the range of colors reproducible by a print device) for the print job accordingly and resubmits the print job to the print device. By selecting an alternate color scheme, the user avoids having the print job canceled or the unacceptable print quality likely to result from the non-optimal consumable condition.

Exemplary System for Adjusting Color Gamut Based on A Consumable Condition

Fig. 1 illustrates an example of a printing system which is suitable for adjusting a color gamut based on the condition of a consumable component of a print device. The system **100** of **Fig. 1** includes a printer device **102** connected to a host computer **104** through a direct or network connection **106**. Network connections **106** can include LANs (local access networks), WANs (wide area networks), or any other suitable communication link. The invention is applicable to various types of color printing devices that make use of consumable components. Therefore, printer device **102** can include devices such as copiers, fax machines, scanners, and the like, and may also include multifunction peripheral (MFP) devices which combine the functionality of two or more peripheral devices into a single device.

In general, the host computer **104** outputs host data to the printer device **102** in a driver format suitable for the device **102**, such as PCL or postscript. The printer device

102 converts the host data and outputs it onto an appropriate recording media, such as paper or transparencies.

Fig. 2 illustrates the printer system **100** in more detail. The printer device **102** has a controller **200** that processes the host data. The controller **200** typically includes a data processing unit or CPU **202**, a volatile memory **204** (i.e., RAM), and a non-volatile memory **206** (e.g., ROM, Flash). Printer device **102** includes a print engine **208** and one or more consumable printing components **210**. Consumable(s) **210** represent print device consumables whose conditions may directly affect which colors are reproducible by the print device **102**. Therefore, consumable(s) **210** generally include toner cartridges, photoconductors, and transfer drums or belts. Other consumables that do not typically affect the reproducible colors of the print device **102**, such as paper and fusers, are not illustrated in **Fig. 2**.

Consumable(s) **210** include monitoring devices **211** located either on the print device **102** or on the consumable **210** itself. The monitoring devices **211** monitor the conditions of consumables either directly or indirectly. The information provided by a consumable monitoring device **211** allows the printer system **100** to know if certain colors are rendered non-reproducible by a non-optimal consumable condition. The printer system **100** can then respond accordingly by presenting options for managing the non-optimal condition, such as suggesting alternate color schemes to compensate for non-reproducible colors.

The controller **200** processes host data and manages the print process by controlling the print engine **208** and consumable(s) **210**. Printer control logic that is typically implemented as printer driver software **212** executing on CPU(s) **202**, controls the print process. The printer driver software **212** is stored in memory **206** and includes an options module that executes to receive information from the monitoring devices on the conditions of consumable(s) **210**. The options module **212** presents options to the user through the host computer **104** for managing a non-optimal consumable condition.

Although the printer driver software **212** and options module generally execute on print device **102**, they may also be stored and execute on the host computer **104** as illustrated by printer driver **220**.

The host computer **104** includes a processor **214**, a volatile memory **216** (i.e., RAM), and a non-volatile memory **218** (e.g., ROM, hard disk, floppy disk, CD-ROM, etc.). The host computer **104** may be implemented, for example, as a general-purpose computer, such as a desktop personal computer, a laptop, a server, and the like. The host computer **104** may implement one or more software-based printer drivers **220** that are stored in non-volatile memory **218** and executed on the processor **214** to configure data into an appropriate format (e.g., PCL, postscript, etc.) and output the formatted data to the printer device **102**.

Exemplary Print Process For Adjusting Color Gamut

Fig. 3 represents a color laser printer **300** as an example print device **102** that may be used in the printing system **100** of **Figs. 1** and **2**. A general printing process will now be described with respect to color laser printer **300** for the purpose of illustrating a context for adjusting color gamut based on the conditions of various consumable components. Consumable components whose conditions are manageable to some extent by color gamut adjustment include color toner cartridges, photoconductors, and transfer drums or belts, as generally represented in **Fig. 3** by components **302**, **306**, and **308**, respectively.

A typical color laser printer **300** produces an image using various colored toners. During an imaging process, a four color image is built sequentially onto a transfer element, such as an intermediate transfer belt (ITB) **308**, before it is finally transferred to the print medium (e.g., paper, transparency) in one pass. The ultimate application of the toners to the print medium is controlled by an electrostatic imaging process.

Color printer **300** houses four toner cartridges **302** in a rotating carousel **304** that is operational with a photoconductor (OPC) drum **306**. Toner cartridges **302** contain the four main toner colors cyan (C), magenta (M), yellow (Y), and black (K). Although the toner cartridges **302** are illustrated as separate devices inserted into rotating carousel **304**, they may additionally be implemented as a single all-in-one color cartridge that includes the four toner colors. For example, the rotating carousel **304** may represent a single all-in-one color cartridge, while toner cartridges **302** represent separate housings within the all-in-one cartridge for accommodating the four color toners. In addition, OPC drum **306** may be implemented as one or more OPC drums. For example, there may be four OPC drums **306**, one to accommodate the transfer of each color toner.

To begin the imaging process, a primary charge roller (PCR) **310** within the OPC drum assembly **312** applies an electrostatic charge to the OPC drum **306**. As the OPC drum **306** rotates, a laser assembly **314** writes the latent image for the first color onto the drum **306** with laser **316**. The toner carousel **304** then puts the first color toner cartridge **302** into position for operation with the OPC drum **306**. Within toner cartridge **302**, an agitator (not shown) guides toner to a developer roller **318**. As the developer roller **318** and OPC drum **306** rotate, the toner is developed to the latent image electrostatically formed on the OPC drum **306**.

Each color image is thus developed one at a time on the OPC drum **306**. Also, each color image is transferred one at a time to the rotating ITB **308** because of attraction from electric charge on a primary transfer roller **320**. Once the four-color image has been built on the ITB **308**, the secondary transfer roller **322** is activated to attract the image away from the ITB **308** and onto the paper in one pass of the ITB **308** over the paper. The paper is guided by guide rollers **324** from a paper tray **326** or external source **328** past the ITB **308** and then through the fuser assembly **330**. The fuser assembly **330** includes two hot rubber fuser rollers **332** that melt the toner,

bonding it to the paper. From the fuser assembly **330**, the paper then exits the printer **300** into the output tray **334**.

With each page printed by the color laser printer **300**, conditions of consumable components such as toner cartridges **302**, OPC drums **306**, and transfer belts **308** deteriorate. At some point, a non-optimal condition of a consumable will result in the inability of the printer **300** to reproduce colors that are otherwise reproducible. The printing system **100** (**Figs. 1** and **2**) responds to a non-optimal consumable condition by presenting options for managing the condition, such as adjusting the color gamut.

Detecting Non-Optimal Consumable Conditions In The Print Process

Non-optimal consumable conditions can be detected in a variety of ways. For example, a monitoring device **211** on a toner cartridge **302** can directly monitor the amount of toner in the cartridge and provide information regarding toner availability to the printing system **100**. Information on toner availability is sent either to the controller **200** on the printer **300** (print device **102**) or to the host computer **104**. In any case, printer driver software **212** (or printer driver software **220**, if on host computer **104**) interprets the information to control the print process. When the monitoring device **211** detects that the toner level is low or completely depleted, the options module in the printer driver software **212** executes to provide options for managing the toner condition, as discussed below.

Another way to determine the availability of toner is through an indirect measure made during a calibration cycle. At any time during the execution of a print job, the printer **300** may run a calibration cycle to ensure that each color toner **302** is transferring properly through the electrostatic imaging process. During a calibration cycle, a test patch of toner is laid down on the photoconductor drum **306** or intermediate transfer belt **308** one color at a time, and examined by a monitoring device **211**. Three test patch patterns are commonly used. The first pattern is a heavy solid test patch,

made up of an area completely filled with a heavy layer of toner. Another pattern is a light solid test patch, made up of an area completely filled with a light layer of toner. The last pattern often used is a series of toner lines laid down over a given area. If a toner color is empty or running low, the monitoring device **211** will provide information indicating the test patch for that particular color is not coming through as expected. Thus, the monitoring device **211** makes an indirect measure of the toner level. The monitoring device **211** signals the printing system **100** about the non-optimal condition for the toner color, and the options module in the printer driver software **212** provides options for managing the condition.

For consumables other than toner cartridges **302**, such as photoconductors **306** and transfer drums or belts **308**, monitoring devices can detect the conditions of the consumables by directly monitoring the effect of a step within the electrophotographic process. In an ideal process, each color toner will electrostatically charge at exactly the same level and have exactly the same charging characteristics. In reality, however, charging characteristics differ between toner colors, and the electrophotographic process is tuned so that voltage bias settings accommodate these differences. Thus, the toner color cyan (C) **302** charges "hot", requiring a higher voltage to enable electrostatic development onto the photoconductor **306** or transfer element **308**, and the toner color yellow (Y) **302** charges "cold", requiring a lower voltage to enable electrostatic development onto the photoconductor **306** or transfer element **308**. Typically, as photoconductors **306** and transfer elements **308** age, their ability to transfer "hot" charging toner colors is the first to fail.

Based on the different charging characteristics between toner colors, the charge balance present on the photoconductor **306** or transfer element **308** before and after the toner is laid down can be monitored to determine if a non-optimal consumable condition exists. The measurement of charge balance can occur during an actual printing process or during a calibration cycle. If the charge balance does not increase or

decrease by the expected amount when a color toner is laid down, there is an indication that the condition of the photoconductor **306** or transfer element **308** has deteriorated to the point where that particular color toner may not be properly reproduced in the printing process. This information about the non-optimal consumable condition permits the printing system **100**, through the options module in the printer driver software **212**, to provide options for managing the condition.

Another way to indirectly monitor the conditions of consumables such as the photoconductor **306** and transfer element **308** involves tracking the life history of the consumable. A consumable will begin having problems transferring a particular toner color during a predictable period of the consumable's lifespan. The predictable period is determined based on known performance characteristics of the consumable type coupled with known charging characteristics of different toner colors. Therefore, a simple monitor that counts the number of rotations of a consumable can be used to provide pertinent life history information about the consumable. The life history information is an indirect measure of the consumable condition. The printing system **100** uses this information to determine when a particular color may no longer be reproducible by the print device **102** . The printing system **100** can then provide options for managing the predicted non-optimal consumable condition.

<u>Adjusting Color Gamut And Other Options For Managing Non-Optimal Consumable Conditions</u>

When a monitoring device **211** signals the printing system **100** of a non-optimal consumable condition anytime prior to or during the execution of a print job, printer driver software executes to manage the consumable condition. As illustrated in **Figs. 2** and **3**, the driver software (**212** or **220**) includes an options module. The driver software is either stored in and executed as part of controller **200** located on the print device **102**, or it is stored in memory **218** and executed on the host computer **104**.

The options module **212** (or **220**) responds to a non-optimal consumable condition first, by determining what color of the four primary toner colors **302** (cyan (C), magenta (M), yellow (Y), and black (K)) is having a problem transferring through the electrophotographic print process. The non-optimal condition can be related to any print device consumable whose condition may directly affect which colors are reproducible by the print device **102**, such as color toner cartridges, photoconductors, and transfer drums or belts. In addition, the non-optimal condition can be detected in various ways, including those already discussed.

After determining which of the four primary toner colors **302** is transferring improperly, the options module warns the user of the problem and provides a visual representation of the print job for display on the host computer **104**. The print job is displayed without using the toner color that is not transferring properly. The options module therefore deactivates the toner color **302** affected by the non-optimal condition for purposes of displaying the non-optimal print job on the host computer **104**.

The options module **212** (or **220**) then provides a set of options to the user for managing the non-optimal consumable condition. These options include canceling the print job, proceeding with the print job using the non-optimal condition, deactivating the toner color affected by the non-optimal condition and proceeding with the print job, printing the print job in grayscale mode, redirecting the print job to an alternate print device, pausing the print job to permit fixing the non-optimal condition, and presenting one or more alternate color schemes to use for the print job.

The user may select from these options based on various factors such as the urgency of the print job. For example, if there is no real urgency to have the print job printed, the user may choose the option of canceling the print job, which simply stops the printing process for the current job and prepares the print device **102** for the next print job.

Selecting the option to proceed with the print job using the non-optimal condition, allows the print device **102** to output the print job even though no action has been taken to remedy the non-optimal condition. Among other things, this option may result in printed output that has streaking or fading in colors that utilize the toner color **302** being affected by the non-optimal condition. For example, if the yellow (Y) toner color **302** is being affected by the non-optimal condition, a print job that is supposed to have a green background may show a background that fades from green to cyan. This occurs because green requires a mixture of cyan (C) and yellow (Y) toners **302**, and the yellow (Y) toner may be working intermittently due to the non-optimal condition.

Deactivating the toner color **302** affected by the non-optimal condition and proceeding with the print job, allows the print device **102** to output the print job without using the toner color **302** being affected by the non-optimal condition. The printed output should therefore look very similar to the visual representation of the print job being displayed on the host computer **104**.

Selecting the option for grayscale mode also allows the print device **102** to output the print job without using the toner color **302** being affected by the non-optimal condition. In general, grayscale is a color mode made up of 256 shades of gray, including absolute black, absolute white, and 254 shades of gray in-between. A print device **102** converts an image having various shades of gray into a halftone image made up of purely black or white dots before printing. Therefore, printing the job in grayscale results in printed output made up of black and white dots portraying the print job in various shades of gray.

The user also has the option of redirecting the print job to an alternate print device or pausing the print job in order to fix the non-optimal condition. After the non-optimal condition is fixed, the print device **102** outputs the print job as usual.

Finally, the user has the option of selecting from one or more alternate color schemes for the print job. The options module **212** (or **220**) suggests the alternate color

schemes based on look-up tables stored as part of the module. The alternate color schemes are presented for viewing and selection on the host computer **104**. Each look-up table corresponds to a non-optimal consumable condition affecting a particular toner color **302**. Each look-up table provides one or more alternate color schemes that are the most likely acceptable alternative to the original color scheme that is no longer reproducible because of the non-optimal consumable condition. In addition, the options module **212** (or **220**) and alternate color schemes in the look-up tables contemplate various other factors of the print job, such as what color text is being used.

For example, if a non-optimal condition occurs that affects the yellow (Y) toner color **302**, and a print job calls for green background and black text, the options module **212** (or **220**) may suggest the use of a blue background instead of green. The options module **212** (or **220**) knows that blue does not require use of the yellow (Y) toner color **302**. In addition, the options module contemplates that only black text is called for in the print job, and that no blue text is used. Therefore, blue may be an acceptable alternative color to use in place of green.

If the user selects an alternate color scheme for the print job, the options module **212** (or **220**) maps the print job to the appropriate look-up table. Therefore, non-reproducible colors that utilize a toner color **302** affected by the non-optimal condition result in reproducible alternative colors from the look-up table. This process adjusts the color gamut of the print device **102** by adjusting the range of colors that is reproducible in printing the print job.

<u>Exemplary Methods Of Adjusting Color Gamut</u>

Having introduced an example system **100** in which adjusting color gamut based on consumable conditions can be implemented, methods for adjusting color gamut and otherwise managing non-optimal consumable conditions will now be described with primary reference to **Figs. 4** and **5**.

Fig. 4A is a flow diagram illustrating an example method of printing in a system **100** such as that in **Figs. 1** and **2**. The method of **Fig. 4A** includes operations that are performed alternately between a host computer **104**, a print device **102(1)**, and an alternate print device **102(2)**. Although the majority of operations are shown as being implemented on the host computer **104**, the control process for most of these operations can be implemented from either the host computer **104** or the print device **102(1)**, through printer driver software stored and executing on either machine.

The example method begins at operation **400** with the host computer **104** submitting a print job to print device **102(1)**. Print device **102(1)** receives the print job at operation **402** and checks for non-optimal conditions in any consumable components at **404**. As previously discussed, non-optimal consumable conditions involve situations such as an empty toner cartridge, a worn photoconductor, or a worn transfer element, all of which can adversely affect the transfer of a toner color through the printing process. Methods for detecting such conditions are discussed more thoroughly with respect to **Fig. 5**.

If consumable conditions are optimal, the print device **102(1)** prints the job at operation **406**. If a non-optimal condition is detected, print device **102(1)** notifies the host computer **104** of the condition at operation **408**. The host computer **104** receives the notification at operation **410** and displays a warning about which toner color is affected by the condition at operation **412**. At operation **414**, the host computer **104** displays the print job as it would appear if printed without the affected toner color.

At operation **416**, options for managing the non-optimal condition are presented to the user through the host computer **104**. By selecting the option of canceling the print job, the user stops the print process at operation **418**. Options to print the job as is, print the job without the affected toner color, and print the job in grayscale, all result in the print device **102(1)** printing the print job in the manner the option indicates at

operation **406**. The resulting printed output with respect to each of these options is described herein above.

The 'pause to correct' option at operation **416** permits the system user to correct the non-optimal condition within the print device **102(1)** at operation **420**, after which the print job is printed as expected at operation **406**. Selecting the 'redirect print job' option permits the user to choose any alternate print device **102(2)** appropriately coupled to the system for printing **422** the print job.

The user can further select the 'alternate color scheme' option at operation **416**. The system, through the host computer **104**, suggests alternate color schemes for the print job at operation **424** and accepts a user-selected color scheme at operation **426**. The host computer **104** resubmits the print job with the alternate color scheme at operation **428**, and the print job is printed at operation **406**.

Details of operation **428**, 'resubmitting the print job with an alternate color scheme', are illustrated in the continuing method shown in **Fig. 4B**. Resubmitting the print job with the alternate color scheme includes the process of adjusting the color gamut of the print device **102(1)** with respect to the current print job. **Fig. 4B** illustrates the basic operations taking place when the color gamut is adjusted.

At operation **430** of **Fig. 4B**, a color look-up table is accessed which corresponds to the non-optimal condition and the selected alternate color scheme. The color gamut (or range of reproducible colors) of the print device **102(1)** is then mapped through the color look-up table and adjusted such that the original color scheme for the print job results in the alternate color scheme. The print job is then printed with the alternate color scheme at operation **406**.

Fig. 5 is a flow diagram illustrating an example method of printing where a color gamut is adjusted because of a non-optimal condition detected in a consumable component of print device **102**. The method begins at operation **500** when the print device **102** receives a print job. The print device **102** has various consumable

components installed whose conditions are checked at operation **502** to determine if any non-optimal conditions exist. Checking the conditions of consumable components occurs in a variety of ways, such as those illustrated in operations **504** through **510**. Any or all of these methods of detecting a non-optimal consumable condition may be employed within print device **102**.

At operation **504**, the toner level for each toner color is monitored. If the availability of a toner color becomes a problem, the print device **102** is made aware of the non-optimal condition for that toner color. At operation **506**, a toner test patch is monitored as an additional way to indicate the availability of the various toner colors.

The effect of a step in the electrophotographic process of print device **102** is monitored at operation **508**. A non-optimal condition in a consumable such as a photoconductor or transfer element can be determined from an unexpected result detected in a step of the electrophotographic process. The number of rotations made by a photoconductor or transfer element is monitored in operation **510**. A non-optimal condition can be presumed from the age of certain consumable components.

At operation **512**, the print job is sent for printing at operation **514** when non-optimal consumable conditions have not been detected. If a non-optimal condition has been detected, the print job is not printed and the printer control is notified of the condition at operation **516**. The print device **102** then receives the print job with an adjusted color gamut from the printer control at operation **518**. The print job is printed using the adjusted color gamut at operation **514**.

Although the description above uses language that is specific to structural features and/or methodological acts, it is to be understood that the invention defined in the appended claims is not limited to the specific features or acts described. Rather, the specific features and acts are disclosed as exemplary forms of implementing the invention.